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(71) Applicant : INTERNATIONAL BUSINESS
MACHINES CORPORATION
Old Orchard Road
Armonk, N.Y. 10504 (US)

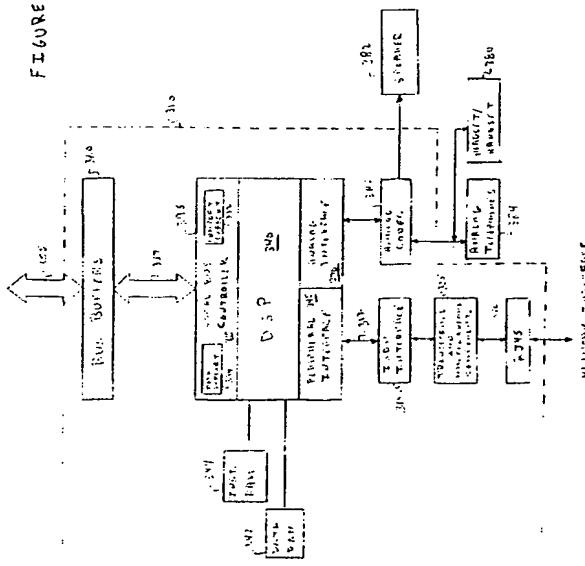
(72) Inventor : Davis, Gordon Taylor
7412 Rainwater Road
Raleigh, NC 27615 (US)
Inventor : Dillon, Charles Bruce
3605 Oates Drive
Raleigh, NC 27604 (US)
Inventor : Marks, Laurence Victoria
4901 North Hills Drive
Raleigh, NC 27612 (US)

⑦ Representative : Lattard, Nicole
Compagnie IBM France
Département de Propriété Intellectuelle
F-06610 La Gaude (FR)

54 System and method for communicating with digital and analog devices via a single digital interface.

(57) The invention is an ISDN terminal equipment which will maintain connectivity with existing analog modems by setting up a voice-grade connection to existing analog modems and using the power of a digital signal Processor DSP to generate the digital equivalent of the analog modem signals for transmission on an ISDN "B" channel.

ESTIMATE 3



vantage of a de facto standard interface for setting and querying modem parameters and status, and for call setup and takedown. The AT command set, originally created by Hayes Corporation, was designed for use with non-programmable terminals. Its purpose was to permit control of the modem from the terminal by use of in-band signals. While this command set has been extended several times, the extensions have been consistent, and the base set has enabled applications to pass commands across the hardware interface. Thus, downward application compatibility was achieved. Expensive application software did not have to be replaced, and custom applications did not have to be rewritten as each new generation of modems was introduced.

Third, the upgrading of asynchronous modems enabled user systems to maintain downward connectivity compatibility. Similar to downward applications compatibility, downward connectivity compatibility is the capability to upgrade modem technology without the addition of devices or software for the specific purpose of achieving workable interface connections between the upgrade modems and the endpoints with which it communicates. Downward connectivity compatibility was achieved by requiring the faster speed modems to communicate at all the previous lower speeds and to maintain a standard communication protocol.

III. Introduction of ISDN

The Integrated Services Digital Network (ISDN) represents an emerging technology which is aimed at replacing the existing analog telephone network with an all digital network capable of handling digital communications as well as voice communications. Numerous suppliers are now offering ISDN interface adapters for personal computers; yet, sales of these products have been disappointingly low. In spite of the wealth of benefits to be achieved by installing ISDN, it has not yet received wide acceptance.

Several interrelated reasons have been identified for preventing the growth of ISDN. These include the high cost of ISDN equipment due to low sales volumes, the high cost and unavailability of ISDN applications, and the unavailability of support services.

Another reason given is that ISDN deployment is expected to be fragmented. Metropolitan areas may be served before rural areas; those areas with relatively strong infrastructures before the weak. This implementation of ISDN "islands" has inhibited ISDN acceptance because users are unwilling to replace a service that has no limitation on calling area with a service that can only reach nearby endpoints.

However, among the various problems impeding the growth of ISDN, connectivity seems to be the most significant factor. Connectivity refers to the ability of data communications equipment to operate and

5 interface with both, the ISDN (digital) network and the analog network. This limitation effectively limits the set of ISDN potential ISDN users to those who create new networks of users that connect to only new endpoints, thereby enabling them to be completely digital.

10 For example, a user that is presently connected to greater than one endpoint who finds his productivity inhibited by bottlenecked data flow to or from a connection-point may be tempted to switch to ISDN as soon as the other endpoint did so. He would be less enthusiastic when he realized that he would have to maintain an analog telephone line and analog modem and adapter as well in order to continue to maintain communications with his other endpoints.

15 Another example of where upgrading present analog systems is more advantageous than converting to ISDN is when a number of users are in a widespread existing network. It is essentially impossible to upgrade all the endpoints in a network at once. However, in an analog network, piecemeal upgrading is possible because of the downward compatibility characteristics discussed above. It is possible, for example, for a user to get a 9600 bps modem to be used at 2400 bps in anticipation of a future network upgrade to 9600 bps.

20 One conventional ISDN adapter is described in commonly owned U.S. Patent No. 4,991,169 to Davis et al. This adapter utilizes an ISDN Primary Rate adapter card with 30 time slots (time-division multiplexing of a 2.048 MHz serial bit stream), and allowed each time slot to be connected to a different analog modem at the other end of the network. This implementation focuses on connecting a computer to a multi-channel environment wherein many lines are terminated for a data base, terminal, or other remote processor access. This system, however, does not provide the capability to connect a computer to digital and analog devices via a single channel in a data link. In addition, the adapter disclosed in the above patent only communicates over channels in the time division multiplex link that are log PCM encoded for voice band analog signals.

25 30 35 40 45 Another conventional solution has been to communicate with both analog and digital devices using multiple interfaces; one for digital and one for analog. To implement such a solution, a system may have an adapter card that has a modem driving the analog interface and digital hardware driving the digital interface. This dual interface function does not have the benefits of a single interface nor does it have the benefits of communicating in an all digital method.

50 55 Another conventional solution is to use digital to analog and analog to digital convertors to convert modem signal to digital form prior to transmitting them over the digital network. One implementation of this approach has been to connect an external modem to an analog port in an ISDN adapter. The ISDN adapter

tions network. The preferred embodiment of the adapter of the present invention dynamically establishes a connection with ISDN endpoints and analog modem endpoints in a Public Switched Telephone Network (PSTN) coupled to an ISDN.

The present invention maintains connectivity in existing communications software via COMM PORT emulation. The ISDN adapter of the present invention utilizes a Digital Signal Processor (DSP) to generate digitized replicas of modem signals which are transmitted over an ISDN B channel. A voice-band bearer service is requested during the ISDN call set-up, which results in the ability to route this B channel to the Public Switched Telephone Network, where in the preferred embodiment it may be connected to an analog modem or Facsimile machine.

II. Introduction of ISDN

A. System Environment

FIGURE 1 illustrates a conceptual view of the ISDN and PSTN from a user connectivity perspective. Various users are connected to ISDN 102 by means of a local interface to a digital pipe of a certain bit rate. Pipes of various sizes are available to satisfy different needs. For example, a residential customer may require only sufficiently capacity to handle a telephone and videotext terminal. A business office, however, may need to connect to the ISDN via an on-premise digital PBX, and will require a much higher capacity digital pipe.

At any given time, the pipe to a user's premises has a fixed capacity, but the traffic on the pipe may be a variable mix up to the capacity limit. Thus a user may access packet-switched or circuit-switched services, as well as other services, in a dynamic mix of signal types and bit rates.

Illustrated in FIGURE 1 are a number of user systems coupled to ISDN 102. First, a workstation 106 which includes the adapter constructed in accordance with the present invention, is connected to ISDN 102 via digital link 107. The preferred embodiment of the present invention is installed in a workstation or personal computer (PC). For purposes of this discussion, the computer platform on which the adapter of the present invention is installed is referred to as a workstation/PC. However, as one skilled in the relevant art will understand, the adaptor of the present invention may be installed in any type of computer platform.

Other users, such as host computer 108, are coupled to ISDN 102 via an ISDN Basic Rate or Primary Rate interface 109 (also discussed below). Other digital endpoints coupled to ISDN 102 include digital facsimile device 110, which is coupled to ISDN 102 via interface 111. Digital facsimile device 110 may be, for example, a G-IV facsimile device or a G-III facsimile

device having an ISDN adapter. Interface 111 may also be Basic Rate or Primary Rate, but is typically a Basic Rate interface. In addition, there may be other devices with which workstation/PC 106 interfaces, such as workstation 114 which is coupled to ISDN 102 via some other type of ISDN interface 115.

FIGURE 1 illustrates ISDN 102 coupled to PSTN 104. PSTN 104 is illustrated as a separate "network." However, there is in actuality a single digital network infrastructure which couples all endpoints shown in FIGURE 1. The distinction is required, however, to illustrate that all analog devices are coupled to the digital network via a analog interface while all digital endpoints are coupled directly to ISDN 102 via a digital interface. The two networks have analogous digital infrastructures which are connected to each other via interface 103.

Each of the analog endpoints which are coupled to PSTN 104 are coupled via what is referred to as a PSTN modem. Each endpoint may require a different data rate. Examples of such analog devices are analog facsimile device 116. Analog facsimile device 116 may be a G-III facsimile which communicates with PSTN 104 via analog link 117 at 9600 bps. Other types of facsimile devices, such as the G-III+, operate at 14,400 bps.

Another analog device is analog workstation/PC 122, which communicates with PSTN 104 over interface 123 via any rate PSTN modem, from 300 to 14,400 bps, for example. Host computer 112 provides on-line database services such as lexis, nexis, prodigy, compuserve, MCI mail, etc. Such systems are coupled to PSTN 104 via interface 113 which operates at 300-14,400 bps data rate. Of course, this can be extended to higher bit rates as they become available.

Also connected to PSTN 104 is workstation 118 which is connected to PSTN 104 via a switched 56 interface via Data Service Unit (DSU) 120. This interface is an example of the various types of digital communications link with which the present invention may interface with.

In a preferred embodiment, the analog device with which the digital modem of the present invention communicates is an analog fax machine 116 or workstation 122. Fax machine 116 and workstation 122 are interfaced to ISDN 102 through a PSTN modem as described above. However, as will become apparent to one of ordinary skill in the relevant art, the present invention may communicate with any device which uses a PSTN modem as the means for interfacing with a network.

It should be noted that the system environment, shown in FIGURE 1 is an exemplary system environment illustrating the various analog and digital devices with which the digital modem of the present invention may interface with. As would be apparent to those skilled in the relevant art, the present invention may

This is illustrated in FIGURE 2 as TE1 224.

As will become apparent to one skilled in the relevant art, the implementation of the adapter of the present invention may be packaged with different functional components in various combinations, including TE1, TE2, TA, NT1, and NT2. For example, if the adapter of the present invention was to be implemented in a computer system having a TE2 with an RS-232 interface, the present invention may be incorporated into a TA.

III. Requirements For A Compatible ISDN Adapter

As described above, the adapter of the present invention is downward application compatible, i.e., compatible with applications programs running on the host workstation/PC; and downward connectivity compatible, i.e., compatible with the endpoint devices. Each of these are discussed below.

A. Downward Application Compatibility

The ISDN adapter of the present invention is completely downward compatible with respect to applications. Downward application compatibility has two parts: physical compatibility and logical compatibility.

Physical compatibility refers to the ability of application programs to physically interface and successfully send data and commands to the adapter. All ISDN TAs meet this criterion, by virtue of their RS-232 (V.24/V.28) connection. Some TE1 devices also meet this criteria, depending upon their implementation.

Logical compatibility refers to the ability of the application program to successfully send commands (specifically, call control) to the adapter. Connectivity to modem applications is achieved via support for the standard COMM Port interface (type 1 or 2) in a PS/2 or other type of personal computer. The adapter provides complete logical compatibility by providing the appearance of a serial port, accepting and responding to AT commands. The adapter of the present invention can support any application that operates through a COMM Port interface connecting to the PSTN interface.

The adapter also supports a high-speed synchronous interface in addition to the COMM PORT interface. This high speed data transfer utilizes more of the facilities of the system bus in the host workstation/PC. Examples of the system bus interface are the ISA bus and the microchannel system buses.

Alternative embodiments of the present invention include the capability to utilize a bus master DMA mechanism for transferring data in parallel between the adapter of the present invention and system memory. This is a more efficient method of transferring data between the system and the adapter since it eliminates the overhead associated with transferring

data via the system bus interface. Thus, higher data rates may be achieved. This is not part of the hardware diagrams.

One skilled in the relevant art will find apparent the ability to configure the present invention to utilize other variations of system interfaces. For example, the present invention may be modified to utilize the enhanced version of ISA bus, referred to as EISA. EISA is often utilized in personal computers which are not IBM compatible. In addition, there are several local buses which are evolving for high speed data transfer, such as VISA and PCI. Another alternative embodiment is the personal computer memory card interface adapter (PCMCIA) which includes a credit card-size plug-in adapter.

B. Downward Connectivity Compatibility

Downward connectivity compatibility refers to the ability of the ISDN-connected device to communicate through the network or networks to another ISDN-connected device or to a PSTN-connected device, such as existing modems in the customer network. A network administrator could migrate users or mainframes or concentrators to ISDN gradually while maintaining connectivity. To date, no product with this capability has been introduced.

The adapter of the present invention enables a user to make calls to, and receive calls from, both digital and analog devices. Making and receiving ISDN calls is straightforward and known in the art. To make or receive a call from the analog network, the present invention utilizes digital signal processing algorithms which generate the appropriate waveform, and then encode the waveform digitally, using the format as used in digital portions of the analog network. Thus, the proper waveform will be emitted to the analog modem.

Generation of the appropriate waveforms in a digital signal processor is a generally accepted technique for implementing PSTN modems. The difference in the present invention is that the waveform is transmitted directly to the network in the digitally encoded format, whereas PSTN modems must convert the digital form to analog via an A/D converter. An analogous situation for signals coming to the adapter exists, whereas the adapter of the present invention accepts digital samples directly from the network, rather than receiving analog signals and using the A/D converter to convert digital samples required for processing by the DSP.

The ISDN adapter has been designed to interwork with today's PSTN. In the PSTN, voice and modem data are carried digitally -- 8000 eight-bit samples every second. The signal is sampled at the point it enters the network, and reconstructed at the point of exit. In an ISDN, the analog/digital conversions are moved outboard to the telephone instrument. For in-

mented as will be apparent to those skilled in the art.

Other options for voice support will be via external devices attached via the "S/T" Interface Passive Bus, such as an ISDN telephone or an NT1 unit which supports an analog POTS (Plain Old Telephone) connection.

A digital ISDN telephone passive bus can be attached, or analog telephones can be connected to a special NT1 that supports the telephone jack. In a preferred embodiment, a handset/headset port is placed on the card enabling the present invention to transmit data on one channel and voice on another.

The network interface complies with CCITT standards (I.430) for the ISDN basic rate interface at the "S/T" reference point (TE1), including Passive Bus connection. The Siemens PEB-2081 will be used for the network interface. VTL logic will convert the synchronous IOM-2 interface (IOM-2 is a time division multiplex interface which multiplexes the B channel with the D channel and the control information into a single serial interface) into the asynchronous AIC interface native to the DSP. AIC-1 on the DSP will be used to connect the network interface to the DSP. A mechanism is implemented which synchronizes a 23.04 MHz clock input to the DSP with the clock signal derived from network timing. This allows an internally generated DSP interrupt to be synchronized with the rate at which data is transferred to and from the network. AIC-2 on the DSP is connected to an analog CODEC chip which provides audio input/output to a handset/headset connector for voice support applications. Audio monitoring of call progress is implemented by connecting the same CODEC output to the system speaker via the Micro Channel Audio pin. The AT/ISA product will include a speaker on the adapter card for monitoring call progress.

V. Software Environment

FIGURE 4 illustrates a functional block diagram of software executing in DSP 340 and the system processor (not shown). That is, the software environment of the present invention is broken into two sections: system software 490 and DSP software 402. As will become readily apparent to one skilled in the art, the functions executing within these sections may be implemented in system software 490, DSP software 402, hardware, or a combination of the three.

Referring to FIGURE 4, the software architecture is based upon the MWAVE Communications Subsystem (described below) running on the MWAVE operating system 402 and MWAVE Manager 410. The MWAVE Communications Subsystem includes the modem control (MDMCNTL) task 426, UART task 430, the asynchronous (ASYNC) task 432, and B channel function tasks 434. Task block 434 includes a plurality of tasks that define the B channel functions. Which of these tasks is actually used is depend-

ent on which driver is selected. Furthermore, the ISDN AT driver 478 is also considered part of the MWAVE Communications subsystem.

5 A. System Software for Basic Functionality

In the preferred embodiment of the present invention, system level software 490 is written in a combination of "C" and assembler programming languages. However, other programming languages now in existence or later developed may be used. In the preferred embodiment of the present invention, the system level software is configured to run in both OS/2 and WINDOWS (under DOS) environments. However, other Workstation or PC environments are equally applicable (e.g., UNIX or Novel Operating Systems).

Referring to FIGURE 4, MWAVE DSP manager 410 provides a high level interface to the DSP 340 in adapter 310. An ISDN port manager 420 supports all ISDN call control functions performed by the present invention. ISDN port manager 420 includes system call control (SCC) task 462, timer task 460, Q.931 task 464, LAPD task 466, and D-channel driver 468.

ISDN port manager 420 performs such functions as dialing, answering incoming calls, and providing a mechanism for linking up the required tasks within block 434 (in conjunction with the selected driver, i.e., the ISDN AT driver 478, the Fax driver 474, V120 driver 482, V120MODEM driver 484, the TCP/IP driver 486, or the HDLC driver 488). The selected driver interacts with the ISDN port manager 420 and the MEIO driver 470. The ISDN port manager 420 uses the MWAVE manager 410 as means for accessing DSP resources when it is doing this linking. Thus, the ISDN port manager 420 activates various tasks executing in the MWAVE operating system 402 through MWAVE manager 410.

These tasks include PC to General Purpose Connector (GPC) task 416, GPC to PC task 418, DMA task 412, port monitor task 408, ACC task 414, and the ISDN TAIO task 404. General purpose connector may also be referred to as a circular buffer.

In a preferred embodiment, a facsimile driver 474 is a feature that is implemented in a substantially similar manner as that described in the MWAVE product literature (available from Texas Instruments). The facsimile driver 474 will be loaded when the user selects a FAX function through a graphical user interface. There are a number of user selectable functions for the adapter in addition to the fax driver 474, the user may activate the modem function 478, the V.120 482, the V.120/Modem 484, the TCP/IP 486, or the HDLC 488.

The ISDN AT Driver 478 is modified to connect to the ISDN port manager 420. The ISDN AT driver 478 is also modified to link different tasks running in the DSP 340 to implement other functional drivers (e.g., V.120 482, V.120/Modem 484 etc.).

tion, and new tasks unique to the ISDN environment.

To insure compatibility with the existing MWAVE tasks (i.e., ability to synchronize GPCs), all real-time tasks will be run under the 9.6 KHz interrupt. Frame manager selection should consider the rate at which data is being processed by the ISDN TAIO task 404. (Frame 6 with the 9.6 KHz interrupt processes 5 bytes per B channel, making N x 6 a convenient frame size to process N x 5 bytes.) The various DSP tasks communicate with each other and to tasks running in the PC using circular buffer structures in DSP memory, and also control block structures in DSP memory.

The MWAVE Operating System is used to control the execution of tasks in the DSP 340.

The VIO BIOS task supports the Log-PCM CODEC chip connected to the AIC2 port of the DSP chip. This interface is used to route call progress tones to the system speaker (Micro Channel Card) or card-mounted speaker (AT/ISA Card) during call setup.

The MWAVE FAX subsystem 474, 476 424, and 422 is integrated into adapter 310 of the present invention unchanged. The TRIO FAX 476 is modified to interact with the MWAVE interface that is provided by the fax driver 474. The MWAVE FAX subsystem supports CCITT T.30 FAX standards for G-III. According to requirements of a specific environment, all or some subset of the functionality described in these standards could be included in the implementation of adapter 310.

When configured for Modem Control, or FAX, the ISDN AT driver 478 or FAX driver 474 is used on the system soft-ware 490. When configured for 56/64 Kbps Digital Interface or Auto Selection via Q.931 response, the Modem Control Task 426 must connect the high-speed protocol tasks to the UART task 430, using the same connections the modem data pump 452, 454 would use to connect to the UART task 430. Additional drivers control the required linking for other functions.

The ISDN TAIO task 404 replaces the TAIO task used in MWAVE, and masks the uniqueness of the ISDN interface from modem or FAX data pumps. The ISDN TAIO task 404 interfaces to the AIC1 hardware via a 128 word circular buffer with a hardware driven pointer. Input and output samples are interleaved within the same buffer. New samples are loaded into and unloaded from the buffer at a rate of 32000 bytes per second in each direction. Each data byte is loaded in the low byte of a DSP word; the high byte is used for synchronization to the ISDN framing.

The ISDN TAIO task 404 must de-multiplex this interface into four distinct channels corresponding to the ISDN D channel, two B channels, and one channel for layer 1 maintenance and control functions. In modem/FAX applications, the ISDN TAIO task 404 must convert ulaw (or Alaw in Europe) samples into linear samples for one of the two B channels coming in.

Subsequent processing will convert 5 samples at 8 KHz into 6 samples at a phase-locked 9.6 KHz rate via an Interpolation/Decimation task to satisfy the modem data pump interface requirements. Interpolation decimation is a well known in the art for sample rate conversion. This dictates the hardware requirement to phase-lock the 23.04 MHz clock input to the DSP (used to generate the 9.6 KHz interrupt to the DSP via internal counter) with the ISDN network clocking so that the interpolation decimation process will be synchronous. It also dictates that the BIOS task runs under the 9.6 KHz Interrupt with a frame size of 6. The frame size is chosen to ensure transmit and receive buffers will not overflow.

The interpolator/decimeter task which exists today runs in frame 24, so it will only need to be activated once every 4 passes through the ISDN TAIO task 404. This may provide incentive to break out the Interpolation/Decimation as a separate task, but the 8 KHz interface must use an ITCB (as a control block) rather than the GPC circular buffer in order to minimize latency. Alternately, the Interpolation/Decimation process could be more efficiently imbedded into the modem receive and transmit filters. The development effort required for this option may be prohibitive.

The other channels de-multiplexed by the ISDN TAIO task 404 will be interfaced directly to GPCs for connection with other tasks (i.e., D channel MAC, B channel protocol, Layer 1 maintenance and control). Either B channel must be connectable to either the loaded modem data pump or the loaded B channel data protocol, depending on configuration and Q.931 responses from the network.

In addition to the data paths provided by the ISDN TAIO task 404, a control path must be provided between the modem control task 426 and the Q.931 task 464 via the existing dialing interface between Modem control and TAIO tasks 404. Both Tone and Pulse dialing commands should be supported across this interface. The ISDN TAIO 404 must also respond to Q.931 call progress responses by generating the appropriate audio tones and placing them on the input GPC buffer connected to the modem data pump and call progress tasks. These tones are also routed to the VIO BIOS task for routing to the system speaker (Micro Channel Card) or card-mounted speaker (AT/ISA Card).

Generation of the following tones are provided: DTMF dialing, Dial tone, Ring back, Busy, Congestion (Fast Busy), Invalid Number DTMF. Dialing and ring back may be eliminated or terminated early because ISDN calls can typically be originated more rapidly than their analog counterparts.

The ACC task 414 running in the DSP software 402 is the primary interface between the ISDN AT Driver 478 in the system software 490 and the other tasks in DSP software 402.

V.120 Rate Adaptation is one B channel protocol

technology -- e.g., remote control access to file server.

(2) Applications not attempted using analog technology (remote use would be impossibly slow) -- e.g., remote X-windows.

This invention allows those applications in the first category to be used in a mixed ISDN/modem environment. The invention allows application users in the second category to communicate with others who do not need those functions.

VII. Alternative Embodiments

The adapter 310 includes a serial port emulation, for application compatibility, and both ISDN and modem connectivity. Alternatively or in addition to the serial port emulation, the adapter 310 may include an AT-bus version to complement the Microchannel version.

Alternative embodiments also include the capability of supporting the transmission and receipt of Group III FAX to the ISDN and PSTN and the transmission and receipt of Group IV FAX to the ISDN.

In addition, the present invention contemplates the use of resident device drivers for OS/2, Windows, and AIX that add a packet-oriented (versus character-oriented) interface, and support Application Programming Interfaces (APIs) such as Network Data Interchange Standard (NDIS) for data, Generic Call Control Interface (GCC) for call control, ETSI (European Telecommunications Standards Institute) ISDN PCI (Programmable Communications Interface), the North American ISDN Users Forum Application Software Interface (ASI), Sun's Teleservices Programming Interface (TPI), Connectivity to Switched-56 services in North America, support for CCITT Recommendation H.221, Frame Structure for a 64 kbits/s Channel in Audiovisual Teleservices, the enabler for CCITT H.261, p*64 motion video, and multiple channel support for CCITT H.221 and audio, to enable teleconferencing.

As will be readily apparent to those skilled in the art, a variety of additional functionality may be added to FIGURE 4 without departing from the spirit and scope of the invention. Specifically, Additional functionality can be added to both the system software 490 and the DSP software 402.

For example, alternative embodiments may replace the COMM PORT interface 332 with a high-performance Bus Master interface which is capable of driving both B Channels at media speed. Such an embodiment is applicable to both MCA Adapter and ISA Adapter.

The ISDN Protocol code can be enhanced to provide additional functions such as supplementary services and X.31 Case B with a single TEI for the D Channel. A Generic Call Control Interface to Q.931 task 464 can be added to connect the ISDN protocol

code to an OS/2 COMM Manager. The interface to Q.931 task 464 must be maintained to allow a FAX application to use one channel while a data connection is maintained on the second channel.

5 A module can be added which will interface to the NDIS interface of OS/2 COMM Manager for connection to an X.25 protocol stack. This module will translate the LAPD used within the standard X.25 stack into a LAPD compatible header so it can easily be multiplexed into the D channel. The multiplexing function may be distributed between this task and the LAPD task 466 as appropriate.

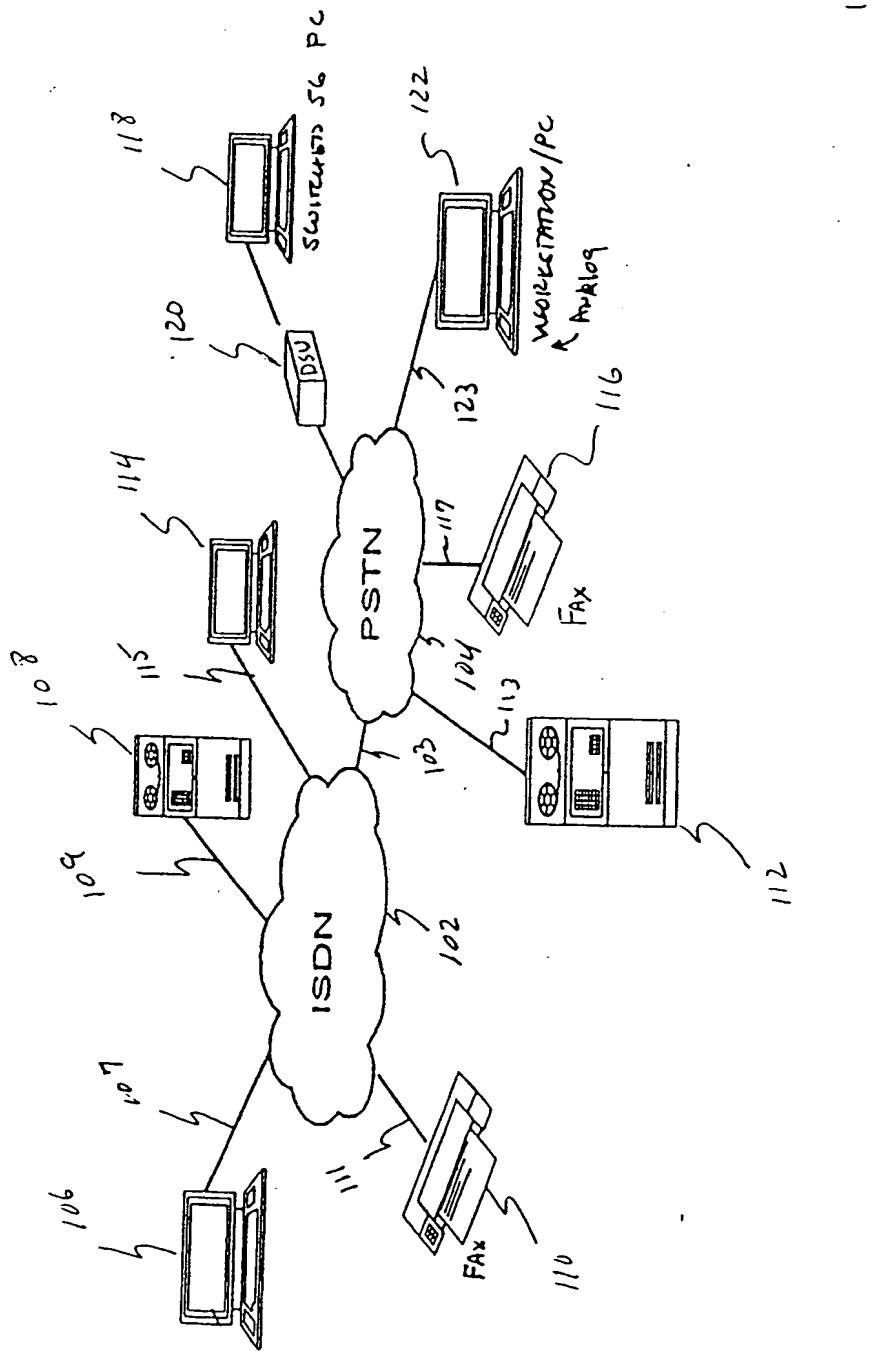
10 A B Channel Driver is required to connect the COMM Manager Protocol stack to the adapter 310. The API for interfacing to the Protocol stack is NDIS. This driver will make full use of the Bus Master capability of the MWAVE chip. This code must be re-entrant in order to support multiple sessions. It supports byte-interleaved concatenation of the two B channels into a single higher speed pipe, as well as independent connections on each channel. Through-put support of full media speed with in-line data compression of at least four to one can be provided, with V.42 bis as the intended compression technique.

15 The UART Task 430 can be replaced by a Bus Master which will connect to a NDIS VMAC Driver in the system software 490. Interfaces to the Modem Control Task 426 will be maintained so the rest of the modem related tasks can be used without change. This creates a high performance bus transport mechanism (BTM).

20 The BMAC Task 450 used with V.120 in FIGURE 4 can be modified to utilize Bus Master data transfers to communicate with the NDIS VMAC Driver via the BTM. The BMAC task 450 will also support interleaved use of two B channels compliant with the Bandwidth On Demand Industry Group (BONDING) standard.

25 The MWAVE TAM (Telephone Answering Machine) task (not shown) is connected to a VIO BIOS and a ISDN TAIO BIOS Interfaces and to the TAM driver running in the system software. The TAM function will be activated if Q.931 detects an incoming voice call, the modem/voice discriminator indicates that the channel contains speech samples, and the headset/handset 380 is not plugged in. A ringing indication should be sent to the speaker 382 for 2 to 6 rings (configurable) before activation of TAM. If the handset 380 is plugged in prior to the configured number of rings, the B channel will be routed to the headset/handset 380. If the handset/handset 380 is already plugged into the adapter 310 when an incoming call is received, and it is determined to be a voice call, the ringing indication will be sent to the speaker 382 for only one ring, after which the call will be connected to the headset/handset 380.

30 If a dialing application requests a voice connection, the ISDN protocol will request B channel service.



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FIGURE 3

